Potential distribution of American black bears in northwest Mexico and implications for their conservation

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Abstract: Defining areas of potential distribution for large carnivores is a critical step for generating conservation strategies. Ecological niche modelling is an important tool for identifying potential areas for conservation of carnivores, such as American black bears (*Ursus americanus*) in the Sierra Madre Occidental (SMOcc) and the Sky Islands (SI) region of Northwest Mexico. Our objective was to define areas and environmental factors that influence bear distribution and understand the causes of their absence. We used GARP (genetic algorithm for rule-set prediction) to define the potential area of distribution using historical and current records of black bear (n = 582) and 23 bioclimatic and physical variables. We obtained a consensus model with a high probability of occurrence and power prediction representing 80% of the SMOcc (221,078 km^2), including the SI region (Sonora and Chihuahua deserts). The ecological dimensions of the model include temperate dry and mixed forest, low rainfall, low temperatures, and elevation above 1,500 m, with considerable slope variation. Information provided by residents of Aguascalientes, Chihuahua, Durango, and Zacatecas indicate that the species was extirpated in central and southwest Durango and Zacatecas about 50 years ago, coinciding with the use of 1080 poison (sodium fluoroacetate) to eradicate livestock predators, combined with habitat loss, fragmentation, and excessive hunting in the region. These factors precipitated the regional extirpation of the species. Areas such as those we have identified may be important sites for the reintroduction of black bears.

Key words: American black bear, distribution, ecological niche, Mexico, Sierra Madre Occidental, Sky Island, *Ursus americanus*

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Numerous tools and approaches have been developed to study species' potential distribution (Guisan and Zimmermann 2000, Araújo and Guisan 2006) and to identify factors that may explain and define such distributions in both geographical and ecological dimensions (Boydston and López-González 2005, Kambhampati and Peterson 2007). Large carnivores are excellent subjects for this type of study due to their large home ranges and their sensitivity to landscape change. Carnivores are environmentally sensitive because of their low fertility and density as well as their limited dispersal capability in open or transformed habitats (Alt et al. 1980, Weaver et al. 1996, Costello et al. 2001, Klenzendorf 2002). These characteristics also make carnivores a species group at risk from large-scale changes in landscape patterns. This is the case of the American black bear (*Ursus americanus*).

Through its evolutionary history, its distribution has been associated with the temperate forests of North America, spanning from the limits of the boreal vegetation in Northern Alaska to highland temperate forests on the edge of tropical vegetation in Mexico (Kolenosky and Strathearn 1987, Kennedy et al. 2002). In Mexico, it is one of the few large carnivores still present and almost exclusively associated with temperate mountain forests of the northwest and northeast regions (Wooding and Ward 1997, Costello et al. 2001). However, there are important geographical differences between proposed models concerning the probable distribution of the black bear in Mexico (compare Hall 1981

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with Larivière 2001), a fact that makes its conservation confusing and lacking specific geographic focus.

The conservation status of the black bear in Mexico is poorly defined. Although the species is considered to be of conservation priority by the Mexican government (Instituto Nacional de Ecología 1999), the subspecies recognized within Mexico (*U. a. eremicus, U. a. machetes,* and *U. a. amblyceps*) have different conservation status. The historical and current geographic distribution of *U. a. machetes* is not known within Sierra Madre Occidental (SMOcc) or the Sky Island (SI) ecoregion of the Sonoran and Chihuahuan deserts. Thus, its conservation status remains uncertain.

Historically, black bears have been subject to several anthropogenic pressures (hunting, poisoning, forest logging, and land-use change) and recently, habitat encroachment and sub-urban development. What was at one time continuous habitat it is now split into many fragments of differing sizes (Jonkel 1978, Wooding and Ward 1997). Several authors believe that species distribution and the population size have been drastically diminished, placing at risk its viability in Mexico (Instituto Nacional de Ecología 1999, Costello et al. 2001).

Conservation strategies for the black bear should be formulated with reliable knowledge of its geographical and ecological distribution. These methods generate spatially explicit models based on relationships between species in geographic space and their relationships to environmental factors within the landscape (Schumaker 1998, Guisan and Zimmermann 2000, Phillips et al. 2006). The resulting models, such as ecological niche models (ENM), have been interpreted as a means of depicting the potential distribution of a species (Kambhampati and Peterson 2007). They are frequently applied in biogeography, conservation biology, species ensemble, climate change, and evolution (Hidalgo-Mihart et al. 2004, Wiens 2004, Soberón and Peterson 2005, Araújo and New 2007, Jíménez-Valverde et al. 2007, Rodríguez et al. 2007, Ortega-Huerta and Peterson 2008).

Ecological niche models, along with geographic information systems, are tools that help in the identification of areas or regions for reintroduction, management, and preservation of priority species such as carnivores (Boydston and López-González 2005, Carroll et al. 2006). This strategy can be taken as the first step toward the development of a species conservation program. Our objective was to build an ecological niche model for the black bear in the SMOcc and SI located in northwest Mexico and southwest USA for the last 50 years. This was done under the premise that subpopulations present in the SMOcc and SMOr (Sierra Madre Oriental) have very distinct genetic differences (Onorato et al. 2007, Varas-Nelson et al. 2010). In addition, we identified environmental factors that define the historical distribution of black bears in geographical and ecological contexts and explored possible causes of extirpation in the SMOcc and SI ecoregions.

Study area

Our study area was delimited by calculating the mean dispersal distances of the black bear as reported by Rogers (1987), Costello et al. (2001), and Allen (2003) in Arizona and New Mexico (~45 km). Based on this figure, we generated a buffer zone in ARCVIEW (Environmental Systems Research Institute 1999) around the SMOcc 45 km wide, perpendicular to the base of the SMOcc at every point. This polygon was 547,218 km^2, and included the ecoregion SMOcc and SI in Mexico and southwestern USA (Fig. 1). The SMOcc is rugged with abrupt, deep slopes toward the Pacific and less abrupt slopes toward the Chihuahuan Desert plateau. Elevation ranges from 1,100–3,900 m (Ferrusquia-Villafranca 1993). The climate varies in extremes from temperate-hot sub-humid in the mountains (20°C summer and −20°C in winter, with occasional snow falls in the higher areas) to semi-dry at the valleys (10°C winter and ~40°C in summer). Total annual precipitation ranges from 500–1,600 mm and relative humidity from 50–60% (García 1988). The dominant vegetation consists of mixed and temperate forests in the highlands; cloud forests in canyons; and chaparral, grasslands, and tropical deciduous forests in the lowlands (Palacio-Prieto et al. 2000, González-Elizondo et al. 2007).

Methods

Input data source and management

We recovered historical and current records on the occurrence of black bears using the database records retrieved by Delfín-Alfonso et al. (2011) and obtained additional records from the Global Biodiversity Information Facility (http://www.gbif.org), the Mammal Network Information System (http://www.manisnet.org), and the ARCTOS

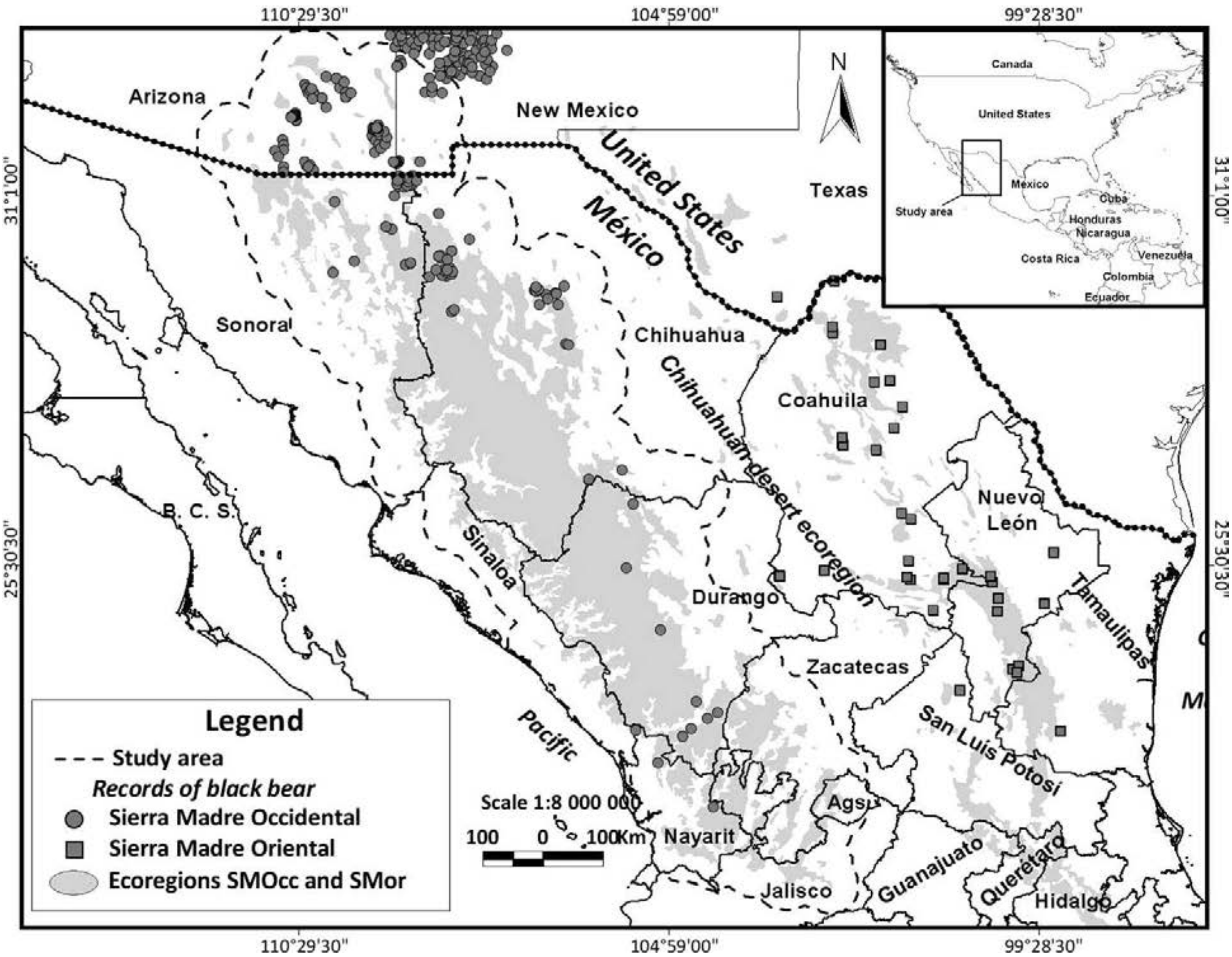

Fig. 1. Study area in the SMOcc, which includes the Sky Islands, from northwest Mexico and the southwest USA.

Multi-Institution-Multi-Collection-Museum Database (http://arctos.database.museum). Records obtained corresponded to scientific collections of national and foreign museums, published records from other sources (reports, scientific publications, gray literature, books, newspaper), records provided by key informants, and reports from government agencies (Table 1) in the last 120 years (1890–2010).

We used 23 environmental variables to generate prediction models: 19 variables corresponded to the interpolation of temperatures and rainfall data (Table 2) from WorldClim (http://www.worldclim.org, ~1950–2000, Hijmans et al. 2005), and 4 variables represented terrain (Table 2) from the US Geological Survey's HYDRO1k dataset (US Geological Survey 2001). All variables had a resolution of 0.0083° pixel (1 km^2/pixel). We also obtained information in the field through interviews to inhabitants and key contacts in part of the Durango and Zacatecas Sierras between 2002 and 2004; Durango, Aguascalientes, and Zacatecas in 2008 and 2009 ($n = 7$), and Chihuahua and Sonora in the summer of 2008 ($n = 29$).

Ecological niche modelling procedure

We used GARP (genetic algorithm for rule-set prediction, Stockwell and Peters 1999; http://www.nhm.ku.edu/desktopgarp) to generate the models. The algorithm seeks the environmental factor set best predicting the occurrence points in the sample, and models vary stochastically between simulations (Peterson 2006). It has been used to successfully predict the geographic distribution of wildlife species in Mexico (Feria and Peterson 2002, Ortíz-Martínez et al. 2008).

Table 1. Institutions that provided data and number of records of black bears in the northwest Mexico and southwest USA study area from 1890–2010.

Data provider	Records	Catalog number
Government agencies		
Arizona Game & Fish Department	131	None
New Mexico Department of Game & Fish	363	None
Comisión Nacional para el Conocimiento y Uso de la Biodiversidad	4	16863, 49733, 60819, 77697
University and research center collections		
Centro de Investigación en Alimentación y Desarrollo, A.C.	3	210801-1, 210801-2, 210801-3
Laboratorio de Vertebrados-Universidad Autónoma de Querétaro	13	None
Field Museum Natural History, Mammals Collections	6	19064, 19012, 22362, 89904, 89905, 89906
Instituto de Biología, UNAM-Colección Nacional de Mamíferos	1	1244
Michigan State University Museum	1	871
Museum of Vertebrate Zoology, University of California, Berkeley	4	121819, 121820, 121821, 128494
Vertebrate Zoology Mammals Collections-National Museum of Natural History-Smithsonian Institution	15	99665, 99338, 98329, 98326, 98325, 98322, 98321, 203206, 177665, 177664, 177663, 177662, 177661, 132195, 117100
The Academy of Natural Sciences of Philadelphia, Mammalogy collection	4	6881, 6882, 6883, 19995
Museum of Comparative Zoology-Harvard University	1	10502
American Museum of Natural History	2	15867, 21592
Printed sources		
Allen 1904 & 1906, Leopold 1958, Baker & Greer 1962, Anderson 1972, Treviño & Jonkel 1986, Vargas 1997, Verdugo 2005, Mendoza 2006, Moreno-Arzate 2008, Sánchez-Mateo et al. 2007, Newspaper El Imparcial 2008 (Sonora State), Lara-Díaz 2010, López-González & Lara-Díaz 2010	29	
Personal communication		
Dr. Carlos López González, (one record, Universidad Autónoma de Quéretaro, Quéretaro, México, 2004, Dr. José Hugo Martínez (one record, Universidad Juárez del Estado de Durango, México, Durango, 1989), Dr. Jorge Servín Martínez (two records, Universidad Juárez del Estado de Durango, México, Durango, 2004 and 2005), Ing. Vidal Lozano (one record, Consultoría Forestal y Ambiental del Ing. Roberto Trujillo, Durango, Dgo., 2007.	5	
Total	582	

We selected only unique records to avoid bias or overestimation of the model during the simulation with GARP (as recommended by E. Martinez-Meyer, Universidad Nacional Autónoma de México, México, D. F. 2009), resulting in using 111 (20.2%) of the 582 records collected. To reduce bias obtained in the GARP model, we divided the study area into a 900-km^2 grid and used only one randomly selected record from each cell. We generated 300 individual models with 1,000 iterations with 0.01 convergence limit per model; from these, we selected the best 30 models based on an omission threshold value of 10% and a commission error tending to the median. In this way, we ensured that the final models balanced errors reducing both over and under prediction (Anderson et al. 2003).

Validating consensus final model

We evaluated the statistical significance of the models by using the protocol of Anderson et al. (2003). We randomly divided the dataset, using 75% of points as training data and holding back the remaining (25%) for model validation. We assessed model fit using the goodness-of-fit χ^2 tests calculated by GARP. Models with high accuracy ($\geq$80%) were selected for further analysis.

Because GARP modelling produces raster layers, we imported these into ArcView (Environmental Systems Research Institute 1999) using Map calculator tools to generate a consensus final model. We also used interview data gathered in the field to visually validate the final model.

Exploration of the ecological niche

The characterization of the ecological niche was accomplished by constructing a database with all environmental layers used to develop the final model. From the dataset extracted from the spatially explicit model, we produced bi-dimensional plots with envi-

Table 2. Comparative values of the niche in the ecological dimension of the final model (summary statistics averages, standard deviations, maximum and minimum values) and geo-referenced records used of black bear in northwest Mexico.

	Final consensus model value			Unique records value (n = 111)		
Variables	Min	Max	Mean (SD)	Min	Max	Mean (SD)
Annual mean temperature, °C	6.7	18.2	14.79 (1.69)	5.4	17.1	12.51 (1.91)
Mean diurnal range, °C	12.1	20.3	17.36 (1.34)	12.8	19.9	16.04 (1.57)
Isothermality	4.3	6.5	5.39 (0.51)	4.3	6	4.89 (0.35)
Temperature seasonality, °C	27.1	74.1	53.32 (13.08)	31.31	82.6	60.95 (8.16)
Max. temperature of warmest month, °C	22.8	36.5	30.91 (3.12)	22.9	35	29.44 (2.63)
Min. temperature of coldest month, °C	−7.9	4.1	−1.29 (2.17)	−13.5	3.8	−3.11 (2.07)
Temperature annual range, °C	22.3	39.4	32.2 (3.89)	22.3	40.6	32.55 (3.04)
Mean temperature of wettest quarter, °C	13.6	24.8	20.62 (2.72)	13.1	24.2	19.55 (2.21)
Mean temperature of driest quarter, °C	6	20	14.62 (3.11)	8	19.5	14.73 (2.76)
Mean temperature of warmest quarter, °C	14.5	25.4	21.41 (2.75)	13.7	25	20.36 (2.22)
Mean temperature of coldest quarter, °C	−0.3	12.5	7.88 (1.98)	−4	11.2	4.85 (2.06)
Annual precipitation, mm	28.1	1000	535.41 (157.23)	251	946	545.4 (114.75)
Precipitation of wettest month, mm	65	241	131.35 (41.44)	44	228	116.87 (26.21)
Precipitation of driest month, mm	2	17	6.75 (2.95)	2	23	8.48 (2.86)
Precipitation seasonality (CV– coefficient of variation)	5	11.5	9.03 (1.4)	4	10.7	7.19 (1.3)
Precipitation of wettest quarter, mm	163	574	327.29 (106.84)	110	575	283.3 (67.47)
Precipitation of driest quarter, mm	10	71	30.08 (10.97)	12	74	40.38 (11.78)
Precipitation of warmest quarter, mm	136	514	277.91 (99.99)	93	518	241.65 (59.25)
Precipitation of coldest quarter, mm	17	213	75.51 (34.16)	29	200	113.89 (39.94)
Elevation, m	1050	3015	1900.74 (450)	1015	2890	1980 (396)
Aspect (0–360°)	0	360	170.62 (101.97)	1.26	359.06	176.37 (105.93)
Slope 0–90° (%)	0	42.6	6.25 (5.37)	1.22	34.84	9.35 (5.73)
Topographic index (rugosity index)	104	1515	422.91 (198.69)	142	727	326.81 (140.98)

ronmental axes that displayed distribution of the niche in ecological space (e.g. annual precipitation vs. elevation). This procedure has been successfully used in other research (Boydston and López-González 2005, Kambhampati and Peterson 2007, Ullah et al. 2007).

Results

Black bear records

We obtained a total of 582 records of black bear (Table 1). Arizona and New Mexico had the greatest number of records (n = 494), followed by Chihuahua (n = 47), Durango (n = 7), and Sonora (n = 31); the states of Jalisco, Nayarit, and Sinaloa had only 1 record/state. We obtained no records from the states of Aguascalientes or Zacatecas. We classified 91% of records obtained as 'current' (1970–2010) and the remaining 9%, from 1890–1970, as 'historical.' Of these, 54 records corresponded with specimens in scientific collections of museums and universities, and 34 records came from reports, scientific publications, gray literature, and personal communication with carnivore specialists of the SMOcc. Sixty six percent of the records were provided by the New Mexico Department of Game and Fish (NMDGF); the second most records, from southeast Arizona, were provided by the Arizona Game and Fish Department (AGFD). All of these originated from bears hunted from 2004 to 2008 in hunting units close to the Mexican border (Table 1).

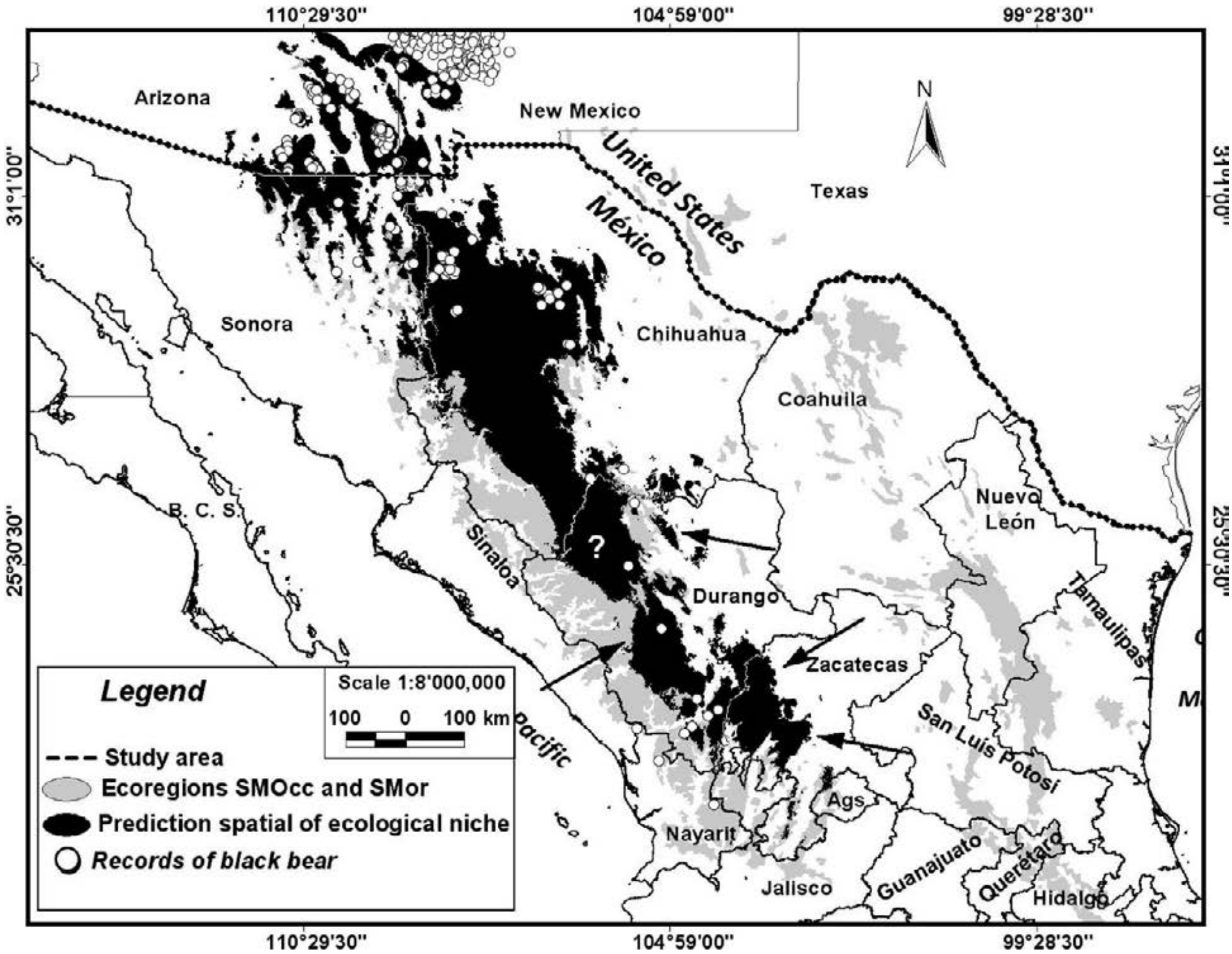

Fig. 2. Map projection of final consensus result for the ecological niche model (black area) of distribution of black bear in the Sky Island and SMOcc in northwest Mexico (white dots indicate confirmed records; arrows indicate areas where species is presumed extirpated locally, question marks represent sites lacking data).

Accuracy and statistical significance of model

The 30 final models range was significant for predicting black bear distribution (χ^2 = 269.319–378.194, $P < 0.001$). We found that 2 records were located outside of the prediction models; however, these were located only about 5 km beyond the boundary of the prediction models in Nayarit state (Fig. 2).

Niche model in the ecological dimensions

Our final consensus model suggests that potential black bear distribution covers 80% (221,078 km^2) of the SMOcc and reveals a wide niche for northwest Mexico and the southwest USA (Fig. 2). Of the 23 physical variables, those that appear relevant and favorable to black bears (Table 2) are mountains with slopes between 6 and 42%, elevation above 1,500 m, annual precipitation between 500 and 1000 mm ($\bar{x}$= 535.41, SD = 157.23 mm), and annual mean temperature <15°C ($\bar{x}$= 14.79, SD = 1.69, Delfín-Alfonso 2011).

The exploration of environmental bi-dimensional plots showed that the distribution of the niche in ecological space (as well as actual species occurrence records) is located in temperate climate conditions. Black bears show a general trend to have a narrow ecological niche in most variables considered in the analysis (Fig. 3).

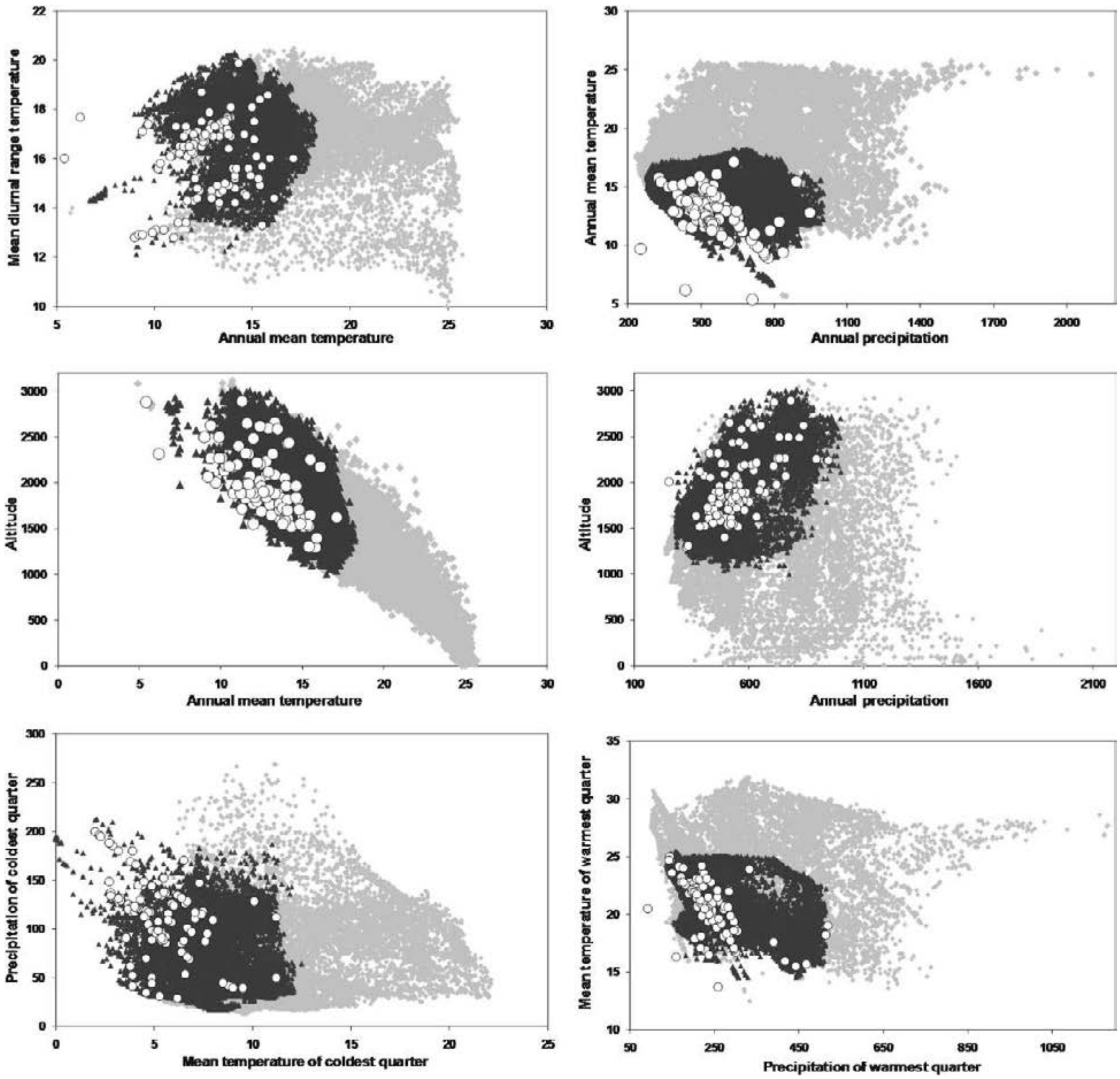

Fig. 3. Exploratory visualization (selected variables) of the black bear niche in environmental space (gray square = availability of environmental conditions, black triangle = final consensus model, open circle = black bear record in ecological space) for temperature in °C, precipitation in mm, and elevation in meters).

Discussion

Black bears are common in many parts of North America, and during the first part of the 20th century were abundant in the northwestern mountains of Mexico (Kennedy et al. 2002). The historical distribution of black bear included most of the USA, southern Canada, and northern Mexico (Hall 1981, Larivière 2001); black bears are associated with temperate forests and arid woodland regions of western North America where populations are linked between mountain ranges covered with coniferous or mixed forests (Maehr 1997, Costello et al. 2001, Larivière 2001). Although distribution of the black bear in the USA is documented by a well managed and current database, data from Mexico is limited, complicating the modelling process (Delfín-Alfonso et al. 2011). During this study, we detected an inadequate systematization of black bear records in Mexico (only 8 records in collection; Table 1), even within the most complete scientific collections. This contrasts with the collections in the USA where government agencies such as the US Fish and Wildlife Service, NMDFG, and AGFD as well as universities and museums maintain databases mostly comprised of updated records.

The distribution of the black bear in northern Mexico was probably greater during the last glacial period than the present. Data from various sources (pack rat [*Neotoma* spp.] middens, tree rings, and lake sediments) indicate that areas of northern Mexico that are presently characterized as arid environments dominated by desert shrubs and succulents were wetter, cooler, and predominantly woodlands or chaparral during in the late Pleistocene and beginning of the Holocene (Metcalfe et al. 2002, Metcalfe 2006). Vegetation types during these periods in the Sonoran and Chihuahuan deserts had substantial areas of pinyon (*Pinus remota, P. monophylla, P. quadrifolia*) and juniper or táscate (*Juniperus occidentalis, J. californica*) woodlands extending to elevations as low as 800 m (Metcalfe 2006). Based on our model, these vegetation types are favorable habitat for black bears. These conditions actually are more common in Durango and Chihuahua (>2,200 m), where the cold fronts dominate winter conditions and correspond to areas where the dominant vegetation is temperate conifer forests or mixed forests of conifers (*Pinus* spp.)–oaks (*Quercus* spp.).

Assuming that the ecological niche for the black bear has not changed considerably, a greater extension of woodland habitat during late Pleistocene and early Holocene would also suggest that the distribution of black bears was greater than at present. Pleistocene-era fossil remains of black bears from a cave in what is now an arid environment in southern Chihuahua where black bears are currently absent provides supporting evidence for a greater distribution of bears during these periods, and of more mesic environmental conditions in northern Mexico (Messing 1986). Reduction of these mesic habitats began with the appearance of arid adapted desert shrubs and succulents in the Chihuahuan desert region 12,000 to 9,000 ^{14}C years before present (Metcalfe 2006). Wooding and Ward (1997) proposed 2 Pleistocene refuges for black bears in North America: Central California and the southeast USA. Recent genetic data show a high genetic diversity of black bears in our study area and a greater number of haplotypes than black bears in the southwest USA (Varas-Nelson 2010), suggesting that that northwest Mexico (Northern Sierra Madre Occidental and particularly the Sierra de San Luis) also served as another important Pleistocene refuge for black bears.

In northwest Mexico and southwest USA, black bears occupy a variety of habitats including chaparral, juniper (*Juniperus* spp.)–oaks and cedar (*Cupressus* spp.), pine forest, open forest, and grassland with dispersed trees (LeCount 1980, Pelton 1989, Costello et al. 2001, Larivière 2001, Maehr et al. 2003, Sierra-Corona et al. 2005, Moreno-Arzate 2008). The estimated potential distribution of black bear presented here agrees with those reported by other authors (Kolenosky and Strathearn 1987, Wooding and Ward 1997, Costello et al. 2001).

Black bears are associated with sites above 1,500 m in areas dominated by temperate forests composed principally of Nearctic elements and are basically absent from arid zones. Biologically, this distribution is in accordance with the bear's thermoregulation adaptations, the availability of food, and the physiological demands of hibernation and reproduction (Bartoskewitz 2001, Benson and Chamberlain 2007). However, populations of black bears in western Mexico are often not considered in the discussion of the distribution of the species. For example, Larivière (2001) and CONABIO (2010), in their distribution maps of black bear, considered a large portion of the Chihuahuan Desert and the Volcanic Trans-Mexican Belt, but neither of these areas have appropriate habitats for black bears. The former actually functions as a biogeographical barrier for many species; thus, we feel that these maps reflected misconceptions, as the species has never been documented in that biogeographical zone. Meanwhile, these authors failed to mention the SMOcc and SI ecoregion.

At a landscape level, food availability is the immediate factor regulating black bear population dynamics and dispersal movements and thus geographic distribution (Rogers 1987, Sandell 1989, Hellgren 1993, Clark et al. 1994, Cunningham et al. 2003, Moreno-Arzate 2008). The frequent changes in the distribution of black bears are conditioned to food and water availability (Sandell 1989, Hellgren and Vaughan 1990), which in turn may be the result of historical events such as land-use changes.

Black bear populations in the SMOcc have been greatly reduced due to deforestation, changes in agricultural practices, intense hunting, and predator control campaigns, and in some areas have been completely extirpated (Fig. 2). In some areas where black bears have been extirpated, such as within Durango, Zacatecas, and Aguascalientes, the probable causes of extirpation were persecution and eradication programs for Mexican wolves (*Canis lupus baileyi*) and coyotes (*Canis latrans*) (Brown 1984). But the question remains, why did such campaigns affect bears? The black bear is considered a generalist omnivore even when taxonomically is grouped with carnivores; principal bear foods are fruits and vegetation (Rogers 1987, Beckmann and Berger 2003). Black bears consume vertebrates often as carrion, not necessarily preying upon them (Raine and Kansas 1990, Hellgren 1993, Stubblefield 1993). During the eradication campaign carried out by the Mexican and US governments (started during the late 1800's, officially began around 1949, and unofficially extended until 1975), baits first with strychnine, and later 1080, were extensively used to kill wolves and coyotes (Molina 1964; Brown 1984, 1996; R. Winslow, NMDGF, Santa Fe, New Mexico, USA, personal communication, 2009). Baits were placed on farm animal carcasses, and butchered pieces were distributed throughout an area. It is highly probable that black bears fed upon these poisoned baits causing their death; a similar explanation may apply to the extirpation of grizzly bears (*U. arctos*) in Mexico (Brown 1996).

It is unknown if such poisoning occurred differently in Mexico than recorded events in Arizona and New Mexico because the use of 1080 and strychnine poisons in Mexico were unrestricted and few records exist of predator carcasses. Although data are spare, we know that 4,649 coyotes were killed with this technique in Sonora alone (Molina 1964). At about this same time, 46 black bears were killed and 50 more were captured by hunting parties using dogs in Arizona in 1947 (Brown 1984). Habitat destruction and fragmentation and the general effects of human presence in black bear habitat were secondary effects but combined to threaten the majority of the black bear sub-populations in Mexico (Instituto Nacional de Ecología 1999).

Field interviews supported these conclusions. We found that in many zones where the model predicted bear presence, residents mentioned that it had been over 50 years since bears had been observed. For example, in southern Durango near the La Michilía Biosphere Reserve and the Sierra of Urica in Zacatecas, informants mentioned that the loss of bears was the result of incidental killing, poisoning with 1080 during the 1950's, loss of habitat caused by the expansion of agriculture, and poor forest management. Therefore, it appears that although black and grizzlies bears were not targets of predator control programs, their populations were also affected (Brown 1984).

Suitable environmental conditions exist for black bears in large parts of the SMOcc, and several areas have potential as sites for their reintroduction. Clearly, black bear populations are restricted and fragmented in Mexico, and the potential distribution model generated here has significant value in understanding how individuals and populations have responded to these historical ecological and anthropogenic processes.

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